FIELD STUDIES OF WINTERTIME WATER MASS MODIFICATION AND TRANSPORT IN THE SEA OF OKHOTSK

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LONG-TERM GOALS

My long-term goal is to understand the 3-dimensional circulation of marginal seas of the N. Pacific Ocean and the air-sea interactions taking place at the surface of these seas. I am particularly interested in wintertime modifications of the ocean by atmosphere and ice formation that lead to the formation of intermediate and deep water masses, and the temporal changes in these interactions that occur on decade-to-century time scales.

OBJECTIVES

The objective of this study was to gather environmental data from the Okhotsk Sea and its adjacent waters in the late winter and early spring of 1995. The Okhotsk Sea is known to be the site of the coldest water in the N. Pacific region; this cold water is presumably produced through interaction with the atmosphere and sea ice. The Okhotsk Sea is generally the site of the most equatorward penetration of sea ice in the world ocean. Due to political restrictions and the severity of the winter in the region, very few high quality observations of the Okhotsk Sea have been made by western scientists. For example, no new data have been added to the NODC archives of temperature and salinity since approximately the 1930s.

APPROACH

In order to study the Okhotsk Sea in late winter, I organized and participated as chief scientist in a joint US-Russian expedition to the Sea in April and May of 1995 aboard the Russian research vessel *Akademik Lavrent'ev*, based at the Pacific Oceanological Institute in Vladivostok, Russia. Ten scientists from the US and 20 scientists from Russia participated in this expedition. CTD and chemical analysis equipment from the US were used to make measurements of temperature, salinity, dissolved oxygen, nutrients, fluorocarbons, carbonate chemistry, helium-3, and tritium at 184 stations in the Okhotsk Sea and Japan Sea during the 47-day cruise.

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WORK COMPLETED

The cruise was quite successful. While the Russian research vessel was in a generally poor state of repair, it worked well enough that the data collected were of uniformly high quality. With the exception of the tritium and helium-3 observations, all cruise data are now in final form. The data have undergone a number of analyses, and final results are now either submitted as papers or exist as manuscripts that are in preparation. The tritium and helium-3 sample analysis is nearly complete (this work is being carried out by Dr. William Jenkins at WHOI), and a preliminary scientific analysis of the Tr-He results are now underway.

RESULTS

A great deal was learned about the water masses and circulation in the Okhotsk Sea and Sea of Japan from this expedition. These results are being submitted to refereed journals in a series of 4 papers. The scientific findings can be summarized as follows: (1) The Okhotsk Sea is a site of very strong diapycnal mixing, driven by strong tidal flows in the vicinity of the major Kurile Straits, and driven by brine-rejection resulting from sea ice in the northern Okhotsk Sea; (2) the deepest waters of the Okhotsk Sea (>3000 m in the Kurile Basin) are weakly ventilated by the atmosphere, but not by deep convection; instead, the tidal mixing is so strong that some atmospheric properties are mixed completely to the bottom; (3) the residence time of the deepest water in the Okohtsk Sea is about 100 years; (4) the Japan Sea is ventilated in some witers all the way to the bottom (>3500 m), probably by a combination of interaction with Siberian air masses in winter and brine rejection/ice formation in the Tatar Strait region; (5) convection to intermediate levels via mixed-layer deepening occurs in the Japan Sea every winter, but it appears from the deep CFC distribution in the Sea that no deep water has been formed since the mid-1960s; and (6) the main area of formation of dense water in the Japan Sea would appear to be the region of Peter the Great Bay off Vladivostok.

IMPACT/APPLICATIONS

The findings of the 1995 expedition led me to become interested in the Japan Sea circulation, and as a result I have been active in helping to organize the ONR DRI on the Japan Sea (see Riser and Ramp, 1996). Additionally, since the 1995 expedition was the first to be allowed to enter the Okhotsk Sea with non-Russian scientists, there has been a great increase in interest in studying the Okhotsk Sea by people outside of Russia. Several people in the US (including myself) are now planning future work in the Okhotsk Sea, and the Japanese are planning a number of major expedtions there over the next 5 years, based on the good working relationship that has been developed with Russian scientists during and subsequent to the 1995 expedition.

TRANSITIONS

The results of this work have been used to help Dr. Jiyan Yang of WHOI test his model of the Okhotsk Sea and sea ice formation (Yang, 1996), and I have been in contact with Dr. Ruth Preller, Dr. Pat Hogan, and Dr. Harley Hurlburt of NRL concerning the use of these data as tests of their models of the western Pacific and Japan and Okhotsk Sea circulations.

RELATED PROJECTS

1. I have provided unpublished manuscripts based on this work to Dr. Ruth Preller of NRL for use in a review article about the marginal seas of the N. Pacific, to appear in an upcoming volume of The Sea (Preller and Hogan, 1997).

2. Prof. Lynne Talley of SIO, Prof. Seelye Martin of UW, and myself, in cooperation with Japanese scientists from Hokkaido University and JAMSTEC, and Russian colleagues at the Far East Regional Hydrometeorological Research Laboratory in Vladivostok, have designed an extensive study of the Okhotsk Sea including moored current measurements in the Kurile Straits, long-term observations on the northern Okhotsk shelf, and current and ACDP observations in the East Sahkalin Current, to begin in 1998. This work has been proposed to NSF in the US. The Japanese have already been funded for their portion of this work and have agreed with the Russians to charter a vessel suitable for these activities.

3. I have submitted a paper to JPO describing descriptive and modeling interpretation of my observations in the Japan Sea (Riser et. al., 1997). Based partially on these results, I have recently been funded by ONR to deploy PALACE floats in the Japan Sea as part of the new Japan Sea DRI.

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